Chapter 1. *Introduction*

Section 1.1. *Research Significance*

1.1.1. Global Carbon Stock and Carbon Source and Sink

"Carbon source" is defined as the process or activity of releasing greenhouse gas to atmosphere. "Carbon sink" is a process, activity or mechanism of removing greenhouse gas, aerosol or greenhouse gas precursor from atmosphere (Guo *et al.*, 1999). Carbon sources and carbon sinks are distributed extremely universally worldwide, from land to oceans; from arable land to forests, from the natural world to human society. The distribution of carbon sources and carbon sinks is affected by such external factors as latitude, climatic conditions and ground cover, and the transformation of carbon sources and carbon sinks prevails (IPCC, 2001). Carbon lies in a state of dynamic balance among the spheres of the earth, including atmosphere, hydrosphere, biosphere and lithosphere. Major carbon stocks include atmosphere carbon stock, ocean carbon stock and land carbon stock. Land carbon stock includes ground organism carbon stock, soil carbon stock and lithosphere carbon stock.

Carbon in atmosphere exists in such forms as CO_2, CH_4 and CO, with a total carbon reserve of about 785 Pg (Janzen, 2004). For several thousand years, atmosphere carbon stock remains relatively stable in the process of flow and inversion among various spheres. In the period of 1750 years before industrialization, the concentration of CO_2 in atmosphere is about 280 ppm. By changing the ways of land utilization, burning fossil fuel and releasing greenhouse gas, human beings have broken the balance of atmosphere carbon cycle. Atmosphere carbon stock increases by 3.5 Pg every year. The concentration of CO_2 in atmosphere is expected to reach over 2 times of the pre-industrialization level by the end of the 21st Century (Janzen, 2004).

The reserve of ocean carbon stock is about 39,000 Pg. Ocean reserve carbon exists

in three forms: 1) Soluble inorganic carbon, e.g. the carbonate of CO_2/CO_3^{2-} and HCO_3^- ion; 2) Soluble organic carbon; 3) Special organic matters. A vast majority of ocean carbon stock is inorganic carbon, about 37,000 Pg; soluble organic carbon is about 1000 Pg (Janzen, 2004). CO_2 of atmosphere carbon stock is soluble in seawater through air-sea exchange and biological action. About 30% - 40% of the carbon emitted by human beings every year is absorbed by ocean, with an annual absorption value of 1.5 - 2.5 Pg (Sundquist, 1993).

Lithosphere carbon stock has the largest reserve, about several thousand Pg. Most of the carbon exists in such forms as carbonate rocks and mantle source carbon, while a small part of the carbon exists in petroleum, natural gas, coal and other organic carbon forms. A vast majority of carbon in lithosphere carbon stock does not participate in global carbon cycle. Since the industrialization, human mining of ores and fuels has released the carbon reserved in lithosphere, which has become the major process of global carbon cycle since the 20th Century. Fossil carbon stock consumption has also become the leading factor that affects the global greenhouse effect.

Terrestrial ecosystem is another important carbon stock of global carbon cycle, with a total carbon reserve of about 3000 Pg. The carbon storage of terrestrial organisms is about 500 Pg. Soil carbon stock includes organic carbon stock and inorganic carbon stock. The organic and inorganic carbon storage of global soil of 0 - 100 cm depth is 1500 and 835 Pg respectively (IPCC, 2001). Soil organic carbon is the most important and active carbon stock in the global terrestrial ecosystem. Present researches into soil carbon stock are chiefly aimed at organic carbon stock. The carbon flux of terrestrial ecosystem-atmosphere depends on the photosynthesis and respiration of plants and the balance among soil microorganisms. These processes are strongly affected by temperature, precipitation, soil texture and nutrient supply. The annual net absorption of land carbon stock is 0.4 Pg (Qu *et al.*, 2003).

1.1.2. Soil Carbon Stock Change and Greenhouse Effect

Soil is one of the cores of terrestrial ecosystem, and the largest carbon stock with the slowest turnover in terrestrial system. The global reserve of soil organic and inorganic carbon stock of 0 - 100 cm depth soil is about 2400 Pg, about 3 - 4 times of

atmosphere carbon stock and 5 times of vegetation system carbon stock (IPCC, 2001; Janzen, 2004; Hutchinson *et al.*, 2007; Feller and Bernoux, 2008). All the small-range change of soil carbon storage can affect global climatic change by emitting greenhouse gas to atmosphere. As the source or sink of atmosphere CO_2, soil is an important factor that controls the increase of the concentration of CO_2 in atmosphere, playing an important role in global researches into carbon cycle.

For several thousand years, atmosphere carbon stock remains relatively stable in the process of flow and inversion among various global spheres, including biosphere, pedosphere, lithosphere and hydrosphere. Due to such processes as burning of fossil fuel, change of land utilization way and deforestation, the development of industrialization emits CO_2 gas to atmosphere without exception, breaking the balance of atmosphere carbon cycle. The fossil carbon stock consumption in the lithosphere and the soil carbon stock release in the pedosphere have become important aspects of increase of atmosphere carbon storage and increase of CO_2 concentration. The fossil carbon stock in the lithosphere has been existing in the crust for several million years, isolated from active carbon cycle, with an available reserve of about 1000 Pg (Janzen, 2004). When the process of industrialization began, due to the continuous intensification of mining activities, the fossil carbon stock which had remained dormant for a long term began to participate in the active process of carbon cycle, releasing more and more CO_2 gas to atmosphere. Before the 20th Century, less than 1 Pg of CO_2 gas was released through burning of fossil fuel and production of cement. Since the 20th Century, the emission of CO_2 gas has been increasing continuously. By the 1990s, the annual emission had reached 7 Pg, becoming a major factor that affects the process of carbon cycle (Marland *et al.*, 2009) (**Figure 1**).

The continuous increase of CO_2 concentration is attributed to the continuous increase of the fossil fuel use. In addition, the destruction of soil carbon balance caused by the change of land utilization ways (deforestation, agricultural expansion, etc.) is also one of the major reasons for the deficiency of soil carbon stock and the rise of the concentration of CO_2 in atmosphere. In the process of industrialization (1850-1990), due to the change of land use, the emission of CO_2 gas increased continuously. Before the 20th Century, the annual emission of CO_2 caused by the change of land utilization ways was 0.5 - 0.7 Pg. By the 1990s, the annual CO_2 emission had ex-

ceeded 2 Pg (Houghton, 2009) (**Figure 2**). In the process of industrialization (1850-2000), the change of land utilization ways brought about a carbon stock consumption of terrestrial ecosystem of about 200 Pg, and a soil carbon stock consumption of about 156 Pg, and the CO_2 emission released by soil to atmosphere carbon stock was equivalent to 1/3 of the total emission caused by human activities (Janzen, 2004; Hutchinson *et al.*, 2007; Feller and Bernoux, 2008).

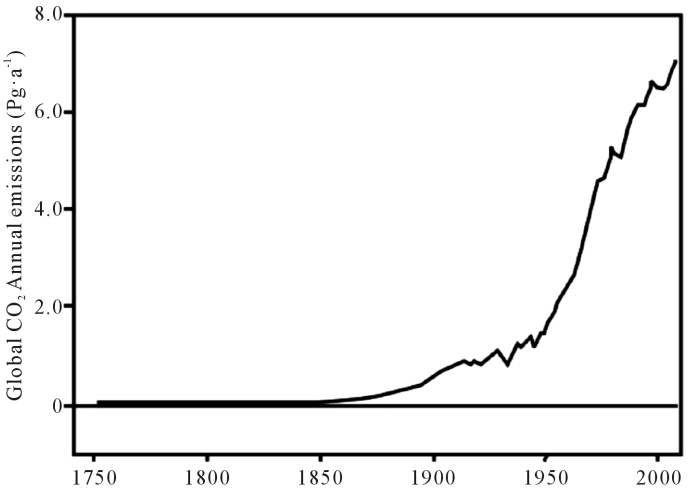

Figure 1. Change of Global CO_2 Annual Emissions from Fossil Fuel Burning and Cement Production (Marland *et al.*, 2009).

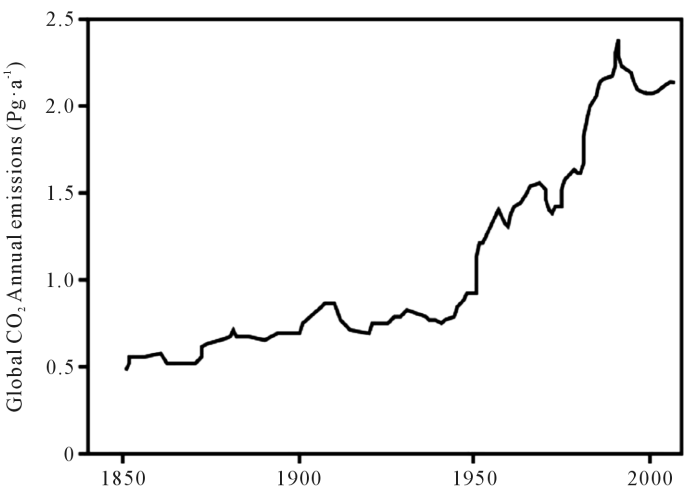

Figure 2. Change of Global CO_2 Annual Emissions from Change of Land Utilization Ways (Houghton, 2009).